NASA Technical Memorandum 89089

AIRCRAFT NOISE SYNTHESIS SYSTEM: VERSION 4 USER INSTRUCTIONS

(NASA-TM-89089) AIRCRAFT NOISE SYNTHESIS SYSTEM: VERSION 4 USER INSTRUCTIONS (NASA) 31 p CSCL 20A
N87-20797
Unclas
G3/71 45378

DAVID A. MCCURDY
BRENDA M. SULLIVAN
ROBERT E. GRANDLE

FEBRUARY 1987

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665-5225

NASA Technical Memorandum 89089

AIRCRAFT NOISE SYNTHESIS SYSTEM: VERSION 4 USER INSTRUCTIONS

DAVID A. MCCURDY
NASA LANGLEY RESEARCH CENTER

BRENDA M. SULLIVAN
THE BIONETICS CORPORATION

ROBERT E. GRANDLE
NASA LANGLEY RESEARCH CENTER

FEBRUARY 1987

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665-5225

AIRCRAFT NOISE SYNTHESIS SYSTEM: VERSION 4 USER INSTRUCTIONS

David A. McCurdy, Brenda M. Sullivan, and Robert E. Grandle

SUMMARY

A modified version of the Aircraft Noise Synthesis System with improved directivity and tonal content modeling has been developed. The synthesis system is used to provide test stimuli for studies of community annoyance to aircraft flyover noise. The computer-based system generates realistic, time-varying audio simulations of aircraft flyover noise at a specified observer location on the ground. The synthesis takes into account the time-varying aircraft position relative to the observer; specified reference spectra consisting of broadband, narrowband, and pure tone components; directivity patterns; Doppler shift; atmospheric effects; and ground effects. These parameters can be specified and controlled in such a way as to generate stimuli in which certain noise characteristics such as duration or tonal content are independently varied while the remaining characteristics such as broadband content are held constant. The modified version of the system provides improved modeling of noise directivity patterns and an increased number of pure tone components. User instructions for the modified version of the synthesis system are provided.

INTRODUCTION

The Aircraft Noise Synthesis System was developed to provide test stimuli for studies of community annoyance response to aircraft flyover noise. Understanding and quantifying the annoyance to aircraft flyover noise experienced by an observer on the ground has been the goal of numerous laboratory and field studies over the past 50 years. Due to the complexity of the noise, it has proven to be a difficult task. Noise level, broadband spectral content, tonal content, duration, Doppler shift, temporal fluctuations, and rise time are among the interrelated characteristics which potentially affect human response to flyover noise. Additional problems are encountered when trying to predict the annoyance to flyover noise of new aircraft which are being designed and have not yet been built or flown. The Aircraft Noise Synthesis System was developed to aid in studying the annoyance effects of different noise characteristics and the annoyance response to future aircraft. The computer-based system generates realistic, time-varying audio simulations of aircraft flyover noise at a specified observer location on the ground. The synthesis takes into account the time-varying aircraft position relative to the observer; specified reference spectra consisting of broadband, narrowband, and pure tone components; directivity patterns; Doppler shift; atmospheric effects; and ground effects. These parameters can be specified and controlled in such a way as to generate stimuli in which individual noise characteristics such as duration or tonal content are independently varied while the remaining characteristics such as broadband content are held constant. The system can also use predictions of noise characteristics to generate simulations of future aircraft.

The original version of this system was developed in 1976 by Time/Data Corporation under contract to the NASA and implemented on a Digital Equipment Corporation PDP-11/15 computer using Time Series Language (TSL) and assembly language. In the early 1980's, a second generation Aircraft Noise Synthesis System with increased precision, capability, and versatility was developed by the NASA and implemented on a Digital Equipment Corporation PDP-11/70 computer using primarily FORTRAN language with a minimum of assembly language. A brief overview of the second generation system is given in figure 1. Figure 2 illustrates the system's hardware configuration. User instructions and a general description of this second generation system are given in reference 1.

Application of the Aircraft Noise Synthesis System to the study of community annoyance response to advanced turboprop aircraft flyover noise has led to the need for improved modeling of noise directivity patterns and an increased number of pure tone components. To meet this need and to make a few minor improvements, the second generation synthesis system software was modified. The modified version of the system allows the directivity patterns to be defined at five degree increments instead of modeled with equations. Also, instead of using one directivity pattern for all the broadband noise, the modified version permits a different directivity pattern to be specified for each one-third-octave band of broadband noise. In addition, the number of pure tone components that can be specified is increased from 20 to 30. Computer capacity limitations required that the number of narrowband random noise components be reduced from 20 to 5 to accommodate these modifications. The new version is called Version 4 or ANOSS4. This paper presents the modified user instructions for Version 4 of the Aircraft Noise Synthesis System.

SYMBOLS AND ABBREVIATIONS

ANOSS	Aircraft Noise Synthesis System
ANOSS4	Version 4 of the Aircraft Noise Synthesis System
ASCII	American Standard Code for Information Interchange
BPI	bits per inch
ips	inches per second
SPL	sound pressure level, dB

VERSION 4 USER INSTRUCTIONS

The synthesis system consists of four sections divided among three programs, ANOSS4, MAKES, and MUSIC. As illustrated in figure 3, the input and spectra generation sections are in the ANOSS4 program. MAKES is the time history generation section and MUSIC is the digital-to-analog conversion section.

Input File Generation

The input section allows the user to enter, manipulate, and store the data required to describe the desired aircraft flyover noise. A flow chart of the section is shown in figure 4. After logging on to the appropiate computer account, the program is initiated with the command:

RUN ANOSS4

The program responds with a series of questions which direct the program to the appropiate subroutines. The first question is:

ENTER PARAMETERS (Y/N)?

A positive (Y) response calls the ENTER subroutine which allows the input data to be entered from a storage device or from the keyboard. After the data are entered, the CHECK subroutine is called to perform a number of checks on the data to insure that the specified simulation represents a realistic situation (e.g., the aircraft does not fly into the ground). A negative (N) response sends the program directly to the CHECK subroutine. After the CHECK subroutine, the program asks:

LIST INPUT (Y/N)?

If answered with a positive (Y) response, subroutine LIST displays the input data on the terminal so that a hard copy may be obtained. The program then asks:

CORRECTIONS (Y/N)?

If answered with a positive (Y) response or if subroutine CHECK detected errors in the input data, subroutine CORRECT is called. This subroutine allows the user to change individual values in the data set. When the corrections are completed, the CHECK subroutine is called again and the "list" and "corrections" questions are repeated. A negative (N) response sends the program to the next question:

COPY INPUT (Y/N)?

The COPY subroutine is called when this question is answered with a positive (Y) response. COPY allows the user to save the data on a storage device for later use or modification. The program then asks:

SET UP COMPLETE? (Y/N or A to abort this run)

A positive (Y) response terminates the Input Section of ANOSS4 and begins the Spectra Generation Section. A negative (N) response sends the program back to the "enter parameters" question so that the user can continue to manipulate the input data. Typing "A" causes the program to end at this point.

The subroutines are further described in the following paragraphs.

ENTER subroutine.- The input data are divided into nine parts. The ENTER subroutine is used to enter the nine parts as a group or individually, either from the keyboard or a storage device. The option to enter parts individually allows the user to combine parts of different data sets that have been previously stored. The subroutine first asks:

WHICH PART OF PARAMETERS DO YOU WISH TO ENTER?

(IF NONE, TYPE IN 0; IF ALL, TYPE IN 10):

To enter an entire set of data the user should respond with a "10". Otherwise, the user types in the number, 1 through 9, of the part he wishes to enter. A "0" response skips the remainder of ENTER and proceeds to the CHECK subroutine. If the response is not "0" the subroutine requests:

ENTER LOCATION OF DATA FOR THIS PART (XXnn:FILENAME.EXT).

(e.g. TERMINAL= TI: ; SYSTEM DISK= FILENAME.EXT):

To enter data item by item from the keyboard the response is "TI:". To read stored data the user specifies the storage device (XXnn:) and the file name and extension (filename.ext) of the data file.

The input values required in each of the parts of the data set are described in the following paragraphs.

PART 1. IDENTIFICATION

1. HEADING (MAXIMUM OF 40 ALPHANUMERIC CHARACTERS):

The heading allows the user to enter a simple description of the data file.

PART 2. OBSERVER LOCATION

1. SIDELINE DISTANCE, METERS:

2. DOWNRANGE DISTANCE, METERS:

3. OBSERVER HEIGHT, METERS (>0.):

Figure 5 illustrates the observer location relative to the flight path of the aircraft. The sideline distance is the perpendicular distance from the observer to the ground track of the aircraft. (The program assumes that the

ground track is a straight line.) No distinction is made as to which side of the ground track the observer is on. The downrange distance is the distance along the ground track from the ground contact point to the point at which a perpendicular line from the observer intersects the ground track. Positive downrange distances place the observer under the flight path. Negative values for downrange distances place the observer uprange of the ground contact point. Observer height specifies how far above the ground the listening apparatus (i.e., the ear or microphone) is located. Observer height must be greater than zero.

PART 3. FLIGHT PATH

1. **NUMBER OF FLIGHT PATH SEGMENTS (1 OR 2):**

2. **AIRCRAFT GROUND SPEED, METERS/SEC (0.<=V0<=340.):**

3. **ANGLE OF SEGMENT A, DEGREES (0.<=PHIA<=90.):**

4. **AIRCRAFT ACCELERATION ON SEGMENT A, METERS/SEC**2:**

5. **TRANSITION DISTANCE, METERS (>0.):**

6. **ANGLE OF SEGMENT B, DEGREES (-90.<=PHIB<=90.):**

7. **AIRCRAFT ACCELERATION ON SEGMENT B, METERS/SEC**2:**

The aircraft flight path can consist of either one or two linear segments. If one segment is selected the program requests parameters 2 through 4 of Part 3. If a two-segment path is selected the program also requests parameters 5 through 7. A two-segment flight path is illustrated in figure 5. (A one-segment path would be illustrated by segment A alone with the simulation outer point lying on segment A.) The aircraft ground speed is the speed of the aircraft at the ground contact point (i.e., the speed at which the aircraft leaves the ground during takeoff or touches down during landing) and is limited to the subsonic range, 0 to 340 m/sec. The angles of segments A and B are the angles between the ground track and the segments. The angle of segment A is limited to 0 to 90 degrees while the angle of segment B can range from -90 to 90 degrees. Aircraft accelerations can be specified for each segment; however, the program will reject values which accelerate the aircraft to supersonic speeds (>340 m) or decelerate it to negative speeds during the time period of the simulation. The transition distance (>0 m) is the distance along the ground track from the ground contact point to the point above which the aircraft moves from one segment to the other.

PART 4. BROADBAND NOISE SPECTRUM

1. **REFERENCE DISTANCE, METERS (>0.):**

2. **REFERENCE SPL AT 90 DEGREES, DB:**

3. RELATIVE SPL OF 10.0 HZ BAND, DB:

ATTENUATION AT 0 DEGREES:

ATTENUATION AT 5 DEGREES:

ATTENUATION AT 10 DEGREES:

.

.

.

ATTENUATION AT 180 DEGREES:

4. RELATIVE SPL OF 12.5 HZ BAND, DB:

To use the same directivity pattern for all 1/3 octave bands as that just entered, type 9999 for the next input.

ATTENUATION AT 0 DEGREES:

ATTENUATION AT 5 DEGREES:

ATTENUATION AT 10 DEGREES:

.

.

.

ATTENUATION AT 180 DEGREES:

5. RELATIVE SPL OF 16.0 HZ BAND, DB:

.

.

.

.

34. RELATIVE SPL OF 12500.0 HZ BAND, DB:

ATTENUATION AT 0 DEGREES:

ATTENUATION AT 5 DEGREES:

ATTENUATION AT 10 DEGREES:

•

•

•

ATTENUATION AT 180 DEGREES:

The broadband random noise spectrum is defined at a point 90 degrees from the jet axis (flight path) and is assumed to be symmetric about the jet axis. The reference distance (>0 m) is the distance from the aircraft to the point at which the one-third-octave band levels are specified. This is illustrated in figure 6. The reference distance parameter allows flexibility in that actual noise measurements made at some known distance from the aircraft can be used or the user may specify the actual noise at an observer by setting the reference distance equal to the distance of closest approach of the aircraft to the observer as defined by the flight path. The one-third-octave band levels are specified in terms of one reference sound pressure level and a relative sound pressure level for each of the bands from 10 Hz to 12500 Hz. The actual level for a given band is the sum of the reference SPL and the relative SPL for the band. This arrangement allows flexibility in that the relative SPL's can be set equal to the actual SPL's (reference SPL=0) or the relative SPL's can be set relative to a single level given by the reference level (e.g., reference SPL=100, relative SPL of 10 Hz band = -10,..., relative SPL of 1000 Hz band = 0,..., relative SPL of 12500 Hz band = -15). In either case, when modifying a data set, all the band levels can be adjusted by a constant amount just by changing the reference SPL.

A directivity pattern about the pitch axis is specified for each one-third-octave band in the broadband spectrum. Figure 6 defines directivity angle in relation to the jet axis. The directivity pattern is entered by specifiying the attenuation for all directivity angles from 0 degrees to 180 degrees in 5 degree increments. These attenuations are relative to the peak level in the directivity pattern for the one-third-octave band under consideration.

If the directivity pattern is the same for all one-third-octave bands, the task of data entry may be shortened considerably. After entering the directivity pattern for the first (10 Hz) band, the program asks for the relative SPL of the 12.5 Hz band. After this is entered, the program displays

To use the same directivity pattern for all 1/3 octave bands as

that just entered, type 9999 for the next input.

and asks for the attenuation at 0 degrees. If 9999 is entered, all subsequent bands are given the same directivity pattern as the 10 Hz band, and the program only requires input of the relative SPL for each band.

Figure 7 illustrates two typical directivity patterns. The directivity corrections based on these attenuations are adjusted by a constant so that the correction applied at 90 degrees to the jet axis equals zero. This is done to avoid changing the noise levels specified at 90 degrees in the input data.

PART 5. NARROWBAND NOISE COMPONENTS

1. ARE NARROWBAND NOISE COMPONENTS REQUIRED (Y/N)?

2. REFERENCE DISTANCE, METERS (>0.):

3. REFERENCE SPL AT 90 DEGREES, DB:

4. NUMBER OF COMPONENTS (1<=IC<=5):

ENTER THE FOLLOWING PARAMETERS FOR EACH NARROWBAND COMPONENT

(SEPARATE PARAMETERS WITH COMMAS, i.e. A,B,C):

A. CENTER FREQUENCY, HZ (9.<=XLST(I,1)<=12500.)

B. RELATIVE SPL, DB

C. BANDWIDTH, HZ (>0.)

5. ENTER DATA FOR COMPONENT NO. 1. :

ATTENUATION AT 0 DEGREES:

ATTENUATION AT 5 DEGREES:

ATTENUATION AT 10 DEGREES:

.

.

.

ATTENUATION AT 180 DEGREES:

A. CENTER FREQUENCY, HZ (9.<=XLST(I,1)<=12500.)

B. RELATIVE SPL, dB

C. BANDWIDTH, HZ (>0.)

6. ENTER DATA FOR COMPONENT NO. 2. :

ATTENUATION AT 0 DEGREES:

ATTENUATION AT 5 DEGREES:

ATTENUATION AT 10 DEGREES:

•

•

•

ATTENUATION AT 180 DEGREES:

•

•

•

•

Since the narrowband random noise components are optional, the user must first indicate whether or not they are to be included. A negative (N) response to line 1 sends the program on to Part 6. A positive (Y) response causes the program to request the parameters describing the narrowband components. The reference distance and reference SPL are defined in the same manner as those for the broadband spectrum in Part 4, but may have different values. One to five narrowband components may be specified. Each component is described in terms of three parameters and a directivity pattern. The center frequency defines the center of the component and may range from 9 Hz to 12500 Hz. The narrowband component is modeled as a triangular power function about the center frequency. The relative SPL is defined in the same manner as in Part 4 and interacts with the reference SPL in the same way. The sum of the reference SPL and the relative SPL is defined to be the summed level of the entire component (i.e., the overall level if the component was the only noise present). The bandwidth is the width of the narrowband component at 3 dB down from the center frequency and is always greater than zero. In terms of the triangular power model, it is the width at which the power is reduced by half. The directivity pattern is defined in terms of the attenuations at 0 degrees to 180 degrees to the jet axis in 5 degree increments in the same way as in Part 4. A different directivity pattern may be specified for each component.

PART 6. PURE TONE COMPONENTS

1. **ARE PURE TONE COMPONENTS REQUIRED (Y/N)?**

2. **REFERENCE DISTANCE, METERS (>0.):**

3. **REFERENCE SPL AT 90 DEGREES, DB:**

4. **NUMBER OF COMPONENTS (1<=ID<=30):**

ENTER THE FOLLOWING PARAMETERS FOR EACH PURE TONE COMPONENT

(SEPARATE PARAMETERS WITH COMMAS, i.e. A,B,C).

A. FREQUENCY, HZ (9.<=YLST(I,1)<=12500.)

B. RELATIVE SPL, DB

C. PHASE, DEGREES

5. ENTER DATA FOR COMPONENT NO. 1. :

ATTENUATION AT 0 DEGREES:

ATTENUATION AT 5 DEGREES:

ATTENUATION AT 10 DEGREES:

.

.

.

ATTENUATION AT 180 DEGREES:

A. FREQUENCY, HZ (9,<=YLST(I,1)<=12500.)

B. RELATIVE SPL, DB

C. PHASE, DEGREES

6. ENTER DATA FOR COMPONENT NO. 2. :

ATTENUATION AT 0 DEGREES:

ATTENUATION AT 5 DEGREES:

ATTENUATION AT 10 DEGREES:

.

.

.

ATTENUATION AT 180 DEGREES:

•

•

•

•

The pure tone components are defined in exactly the same manner as the narrowband random noise components except that a phase angle is specified instead of a bandwidth. The reference distance, reference SPL, and directivity patterns can be different from those used to define the other noise components. Up to 30 pure tone components may be specified.

PART 7. PULSE COMPONENTS

1. ARE PULSE COMPONENTS REQUIRED (Y/N)?

This section is included for future expansion of the synthesis system. Only a negative (N) response is accepted.

PART 8. GROUND ATTENUATION PARAMETERS

1. GROUND FLOW RESISTANCE, KILOGRAMS/SEC*METER3**

(100,000<=GFR<=500,000):

2. INCOHERENCE CONSTANT (0.001<=REFCO<=0.1):

3. NOISE SOURCE HEIGHT, METERS (>0.):

The gound flow resistance is the specific flow resistance of the ground (ref. 2, 3). The value, which varies with the type of surface, ranges from 100,000 to 500,000 kg/sec-m^3. A value of 150,000 is typical. The incoherence constant, which ranges from 0.001 to 0.1, is an empirical quantity which limits cancellation effects (ref. 3). Cancellation effects decrease as the constant increases. A typical value is 0.01. The noise source height (>0 m) is the distance between the ground and the noise source (e.g., the engine) when the aircraft is on the ground. The primary purpose of this parameter is to prevent an error from occurring in the ground effects subroutine. Therefore, any value greater than zero is acceptable and a representative value is not necessary (i.e., using a value such as 0.01 m avoids the error and does not impact the flight path calculations).

PART 9. SYNTHESIS PARAMETERS

1. **START TIME, SEC (>=0. FOR TAKEOFFS, <0. FOR LANDINGS):**

2. **LENGTH OF FLIGHT, SEC (>0.):**

3. **LENGTH OF TAPER, SEC (>=0.):**

4. **SAMPLE RATE, HZ (>0.):**

5. **NUMBER OF FREQUENCY INTERVALS (1024., 2048., OR 4096.):**

Time is defined to be zero when the aircraft is at the ground contact point (i.e., the point at which the aircraft leaves the ground during takeoff or touches down during landing). The start time parameter is greater than zero for takeoffs and less than zero for landings. Length of flight (>0 sec) is the amount of time the aircraft is flown along the flight path for the simulation. For example, a start time of 10 sec with a 30 sec length of flight simulates a takeoff from a point 10 sec after the aircraft leaves the ground to the point where the aircraft is located 40 sec after it leaves the ground. A start time of -50 sec with a 45 sec length of flight simulates a landing from a point 50 sec prior to touchdown to a point 5 sec prior to touchdown.

To avoid an abrupt start and stop of the noise simulation, the synthesis program allows the noise level to be tapered up from zero to the calculated value at the beginning of the simulation and back down to zero at the end of the simulation. Length of taper (>=0 sec) is the amount of time over which each taper is done. The length of taper must be less than or equal to one half the duration of the simulated noise. The noise duration may be slightly different from the specified length of flight since the distance between the aircraft and observer usually varies during the simulation.

The sample rate is the number of points produced per second in the time domain. It should be set to slightly more than twice the maximum frequency to be reproduced. Since the system is programmed for a maximum frequency of 12,500 Hz, the sample rate is usually set to 26,000 Hz.

The number of frequency intervals is the number of intervals into which the frequency range is divided (i.e., 12,500 is divided by 1024, 2048, or 4096). The number of intervals, which must be a power of two, is limited to 1024, 2048, or 4096. The best frequency resolution is obtained by using 4096, which defines a point every 3.05 Hz. However, the higher the resolution, the longer the program takes to execute.

<u>CHECK subroutine</u>.- This subroutine checks for errors that result from the interaction of different input parameters. An error message is printed for each error that occurs in the data. Each of these messages, along with an explanation, is listed below.

ERROR 1: TIME OF SIMULATION END FOR LANDING IS GREATER THAN ZERO.

The length of flight is greater than the simulation time allowed by the landing start time (e.g., start time = -30 sec, length of flight = 40 sec). This results in the aircraft immediately taking off after touching down.

ERROR 2: GROUND VELOCITY AND A-SEGMENT ACCELERATION ARE BOTH ZERO.

Both the aircraft ground speed and the aircraft acceleration on segment A are zero. This results in the aircraft not moving.

ERROR 3: VELOCITY AT POINT 3 IS LESS THAN ZERO.

The aircraft speed at the simulation outer point (i.e., point 3, the simulation end point for takeoffs or the simulation start point for landings) is less than zero. The aircraft cannot fly at negative speeds.

ERROR 4: VELOCITY AT POINT 3 IS GREATER THAN OR EQUAL TO THE SPEED OF SOUND.

The aircraft speed at the simulation outer point (i.e., point 3, the simulation end point for takeoffs or the simulation start point for landings) is supersonic. The program is limited to subsonic speeds.

ERROR 5: SQUARE ROOT RADICAL IN T2 CALCULATIONS IS NEGATIVE. INPUT ERROR CHECK SUBROUTINE TERMINATED EARLY.

When a two-segment flight path is specified, this error check insures that a square root of a negative number does not occur in the quadratic equation solution used to determine the time at which the aircraft is at the transition point (point 2). This error terminates the subroutine immediately.

ERROR 6: VELOCITY AT POINT 2 IS LESS THAN ZERO.

The aircraft speed at the transition point of a two-segment flight path (i.e., point 2, the point at which segments A and B meet) is less than zero. The aircraft cannot fly at negative speeds.

ERROR 7: VELOCITY AT POINT 2 IS GREATER THAN OR EQUAL TO THE SPEED OF SOUND.

The aircraft speed at the transition point of a two-segment flight path (i.e., point 2, the point at which segments A and B meet) is supersonic. The program is limited to subsonic speeds.

ERROR 8: VELOCITY AT POINT 3 AND B-SEGMENT ACCELERATION ARE BOTH EQUAL TO ZERO.

A two-segment flight path is specified and both the aircraft speed at the simulation outer point (i.e., point 3, the simulation end point for takeoffs or the simulation start point for landings) and the aircraft acceleration on segment B are zero. This results in the aircraft not moving.

ERROR 9: ALTITUDE AT POINT 3 IS LESS THAN THE NOISE SOURCE HEIGHT.

The aircraft altitude at the simulation outer point (i.e., point 3, the simulation end point for takeoffs or the simulation start point for landings) is less than the noise source height. The aircraft is below ground level.

ERROR 13: SPECIFIED LENGTH OF TAPER IS GREATER THAN ONE HALF THE TOTAL TIME THAT THE NOISE ARRIVES AT THE OBSERVER.

The program requires that the noise level be allowed to reach its full value. Therefore, the length of taper must be less than or equal to one half the duration of the simulated noise. The noise duration may be slightly different from the specified length of flight since the distance between the aircraft and observer usually varies during the simulation.

When a two segment flight path is specified, one of the following notes is displayed to inform the user which flight segments are included in the specified simulation times.

NOTE 1: SPECIFIED TIME LIMITS SIMULATE FLIGHT ON BOTH SEGMENTS A AND B.

NOTE 2: SPECIFIED TIME LIMITS SIMULATE FLIGHT ON SEGMENT A ONLY.

NOTE 3: SPECIFIED TIME LIMITS SIMULATE FLIGHT ON

SEGMENT B ONLY.

LIST subroutine.- The LIST subroutine displays the input data on the terminal in a format similar to that used by the ENTER subroutine. A hard copy of the input data can then be made from the screen.

CORRECT subroutine.- The CORRECT subroutine allows the user to change individual input values by specifying the associated part and line numbers. The changes can be made in any order. The subroutine first asks which part of the input is to be changed.

ENTER PART OF PARAMETERS (1-9) YOU WISH TO CORRECT (IF

FINISHED WITH CORRECTIONS, ENTER 0):

A response of zero completes the correction routine and the CHECK subroutine is called. A response of one through nine causes the subroutine to ask for the line number of the input value to be changed.

ENTER NUMBER OF LINE YOU WISH TO CORRECT (IF NONE, ENTER 0):

A zero response causes the program to ask again for a part number. Otherwise the subroutine prints out the part and line description (as used in subroutine ENTER) and waits for a new value of the parameter to be entered. After the new value is entered the program requests the line number of the next input value to be changed. This is repeated until a zero response is given to the line number request; then the part number request is displayed. The correction process is terminated by giving a zero response to the part number request.

If the number of flight path segments is changed, the subroutine automatically deletes the extra input (from two segments to one) or asks for the needed additional input (from one segment to two).

Similiarly, if the requirement for narrowband random noise components or pure tone components is changed (part 5 or 6, line 1), the subroutine deletes the component descriptions (changed from required to not required) or requests the input values needed to describe the components (changed from not required to required).

If the number of narrowband random noise components or pure tone components is changed (part 5 or 6, line 4) the subroutine deletes or adds components as required. If the number of components is reduced, the subroutine asks which components (by line number) are to be deleted. If the number of components is increased the subroutine requests the input values needed to describe each additional component.

COPY subroutine.- The COPY subroutine allows the user to save the input data on a storage device for later use or modification. The subroutine first asks where to store the data.

WHERE DO YOU WANT DATA COPIED (XXnn:FILENAME.EXT)?

(e.g. SYSTEM DISK= FILENAME.EXT):

The format used to specify the storage location is "XXnn:filename.ext" where "XXnn:" is the device specification and "filename.ext" is the name of the file and extension chosen by the user. Next, the subroutine asks which part of the input parameters is to be stored.

WHICH PART OF PARAMETERS (1-9) DO YOU WISH TO COPY?

(IF NONE, TYPE IN 0; IF ALL, TYPE IN 10):

The subroutine allows the user to store one or more individual parts of the input parameters at the specified location. A response of one to nine causes the subroutine to store that part and then repeat the question so that additional parts can be stored. A response of ten causes the subroutine to store all nine parts of the input. After a zero or ten response the subroutine asks if the user wants to store the data on another device or file.

DO YOU WANT TO COPY DATA TO ANOTHER LOCATION (Y/N)?

A negative (N) response ends the subroutine. A positive (Y) response causes the subroutine to cycle and request another storage location.

Spectra File Generation

The spectra generation section calculates and stores a series of spectra representing the noise at the observer over the duration of the flight. Only three user inputs are required in this section. First the program requests the storage location for the spectra file.

ENTER SPECTRA FILE LOCATION (XXnn:FILENAME.EXT)

(e.g. SYSTEM DISK= FILENAME.EXT):

The format used to specify the storage location is "XXnn:filename.ext" where "XXnn:" is the device specification and "filename.ext" is the name of the file and extension chosen by the user. If the same device is used, the filename or extension of the spectra file should be different from that of the input file. Otherwise, the input file could be destroyed. Next the program asks:

DO YOU WANT EXTENDED PRINTOUT (0) OR SHORT FORM PRINTOUT (1)?

As the spectra are generated and stored, the program displays the values of parameters describing the initial arrangement and each of the spectra. The answer to this question determines how many parameters are displayed. A "0" response displays all the parameters that are available. A "1" response displays a smaller set of parameters. This output is used primarily when modifying the program, but does give an indication of the progress of the program.

Also for the purpose of checking program modifications, the program gives the user the option to display the pressure distribution of the final discrete frequency random noise spectrum.

DO YOU WANT P(K) WRITTEN OUT (Y/N)?

Since each spectrum contains a number of pressure values equal to the number of frequency intervals (1024, 2048, or 4096), the user will normally answer with a negative (N) response to this question. If a positive (Y) response is given, the pressure distribution is written out in ASCII to the file TESTXX.DAT.

When the program has finished generating the spectra file, it displays:

NORMAL END OF ANOSS PROGRAM.

This concludes the spectra generation section and the ANOSS4 program.

Time History File Generation

The time history generation section converts from the frequency domain to the time domain by performing a Fourier transform on the data in the spectra file. A file containing the digital time history of the noise at the observer is created on magnetic tape. After logging on to the appropiate computer account and prior to starting the program, the user must place a digital, one-half inch, nine track, magnetic tape on the tape drive. After physically putting the tape on the drive, the user must mount the drive to the user's account and terminal using the appropriate computer system command. For the current system, the command is:

MOU MM:/FOR

The digital tape on the drive must be initialized as a Disk Operating System (DOS) formatted tape at 1600 BPI. A previously initialized ANOSS data tape need not be re-initialized. If a previously initialized ANOSS data tape is not used, then a new tape should be used and must be initialized. The following commands are used to initialize a new tape on the current system. The first command is:

FLX

The computer responds with the prompt:

FLX>

In reply to the prompt, the second command is given:

MM:/DO/DNS:1600/ZE

Next, exit the FLX mode and return to the standard prompt by typing <control> and <Z> at the same time. The tape is now ready for use with the program.

The program is initiated with the command:

RUN MAKES

The program responds by asking for the location of the spectra file.

Enter spectra file name :

This is the file specified by the user in program ANOSS4 for storing the calculated spectra. The format used is "XXnn:filename.ext", where "XXnn:" is the device specification and "filename.ext" is the name of the file and extension chosen by the user.

After the file name is entered, the generation of the time history begins. As the time history is generated, the program displays the values of several parameters associated with the transformation of each spectrum. This output is used primarily when modifying the program, but does give an indication of the progress of the program. When finished calculating the time history, the program displays:

MOUNT TAPE PLEASE

To insure proper operation of the program and tape drive, the tape should be, as indicated earlier, mounted and initialized prior to starting the program. Attempting to mount and initialize the tape at this point is usually unsuccessful, resulting in loss of the data generated.

When the tape drive is ready, the program displays:

WRITING HEADER

The time history is then written to the tape and the MAKES program ends. The program can be repeated and additional time histories stored on the same tape. A computer system command file or batch job can be created to automatically make multiple runs with this program using different spectra files. One way to do this is for a privileged user to install the MAKES program as a known task to the system. The command for this is:

INS MAKES/TASK=...MAK

Then the following line can be placed in a command procedure or a batch job for each file to be done:

MAK XXnn:filename.ext

"XXnn:filename.ext" is the previously defined file specification. The number of runs in a command file or batch job is limited only by the capacity of the digital magnetic tape.

Analog Signal Generation

The digital-to-analog conversion section uses a digital-to-analog converter to produce an analog noise signal from the digital time history stored on magnetic tape. This analog signal can be played in real time through a sound reproduction system and/or recorded for later use. The magnetic tape on which the time history file is stored is placed on the tape drive and, after the user logs on to the appropiate computer account, the drive is mounted to the user's account and terminal using the command:

MOU MM:/FOR

Before the program is used certain devices must be correctly connected and set to the remote mode. The Adret frequency synthesizer must be on, set to remote, and its output connected to the clock input of the digital-to-analog converter. The Votrax voice synthesizer's input must be connected to a terminal port on the computer and its output connected to a channel of the analog tape recorder. The output of the digital-to-analog converter must be connected to another of the analog tape recorder's channels. Once these devices are properly connected and set up and the digital tape has been mounted on the tape drive, the program is initiated with the command:

RUN MUSIC

The time histories on the tape are each identified by a number representing their order on the tape. The program asks:

WHICH FILE # ON TAPE ?

The user responds with the file number and the program asks:

WHAT FREQUENCY ?

This question refers to the sample rate (in Hz) specified in the input section (part 9, line 4). For the analog noise signal to have the correct frequency range and duration the number entered here must be the same as that used in the input data. (Entering a different frequency here will cause a shift of all noise frequencies by the ratio of the input sample rate frequency and the frequency entered here. It will also result in a change in the length of the flyover by the same ratio). After the number is entered, the program locates the file on tape and displays:

READY TO PLAY HIT CR TO START

To play the analog noise signal, the user presses the carriage return key. The program then displays some information describing the file and plays the file. When finished playing the file the program cycles and again requests a file number. The program is terminated by typing <control> and <Z> at the same time.

Consecutive flyovers on the digital tape may be played during one program run by using the program MUSIC2 in place of MUSIC. Instead of asking which file number, MUSIC2 asks how many files are to be played. The program starts with the next file found on the digital tape.

CONCLUDING REMARKS

The modified version (ANOSS4) of the Aircraft Noise Synthesis System is operational. Several advanced turboprop aircraft flyover noise simulations utilizing the improved modeling of noise directivity patterns and the increased number of pure tone components have been produced.

REFERENCES

1. David A. McCurdy and Robert E. Grandle, "Aircraft Noise Synthesis System," NASA TM 89040, February 1987.

2. M. E. Delany and E. N. Bazley, "Acoustical Properties of Fibrous Absorbent Materials," Applied Acoustics, vol. 3, no. 2, April 1970, pp. 105-116.

3. William E. Zorumski, "Aircraft Noise Prediction Program Theoretical Manual," NASA TM 83199, February 1982.

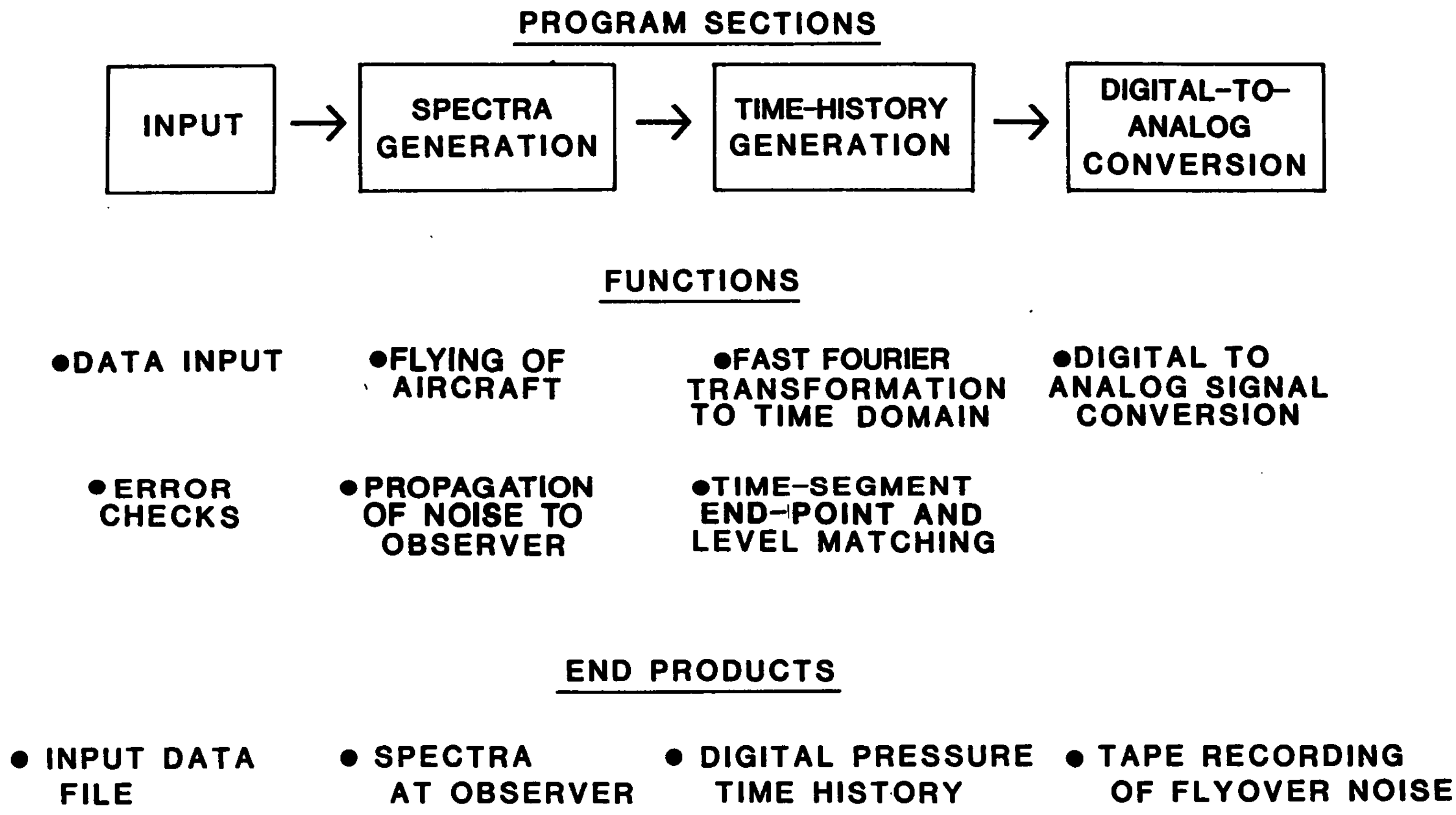


Figure 1. - Aircraft Noise Synthesis System organization.

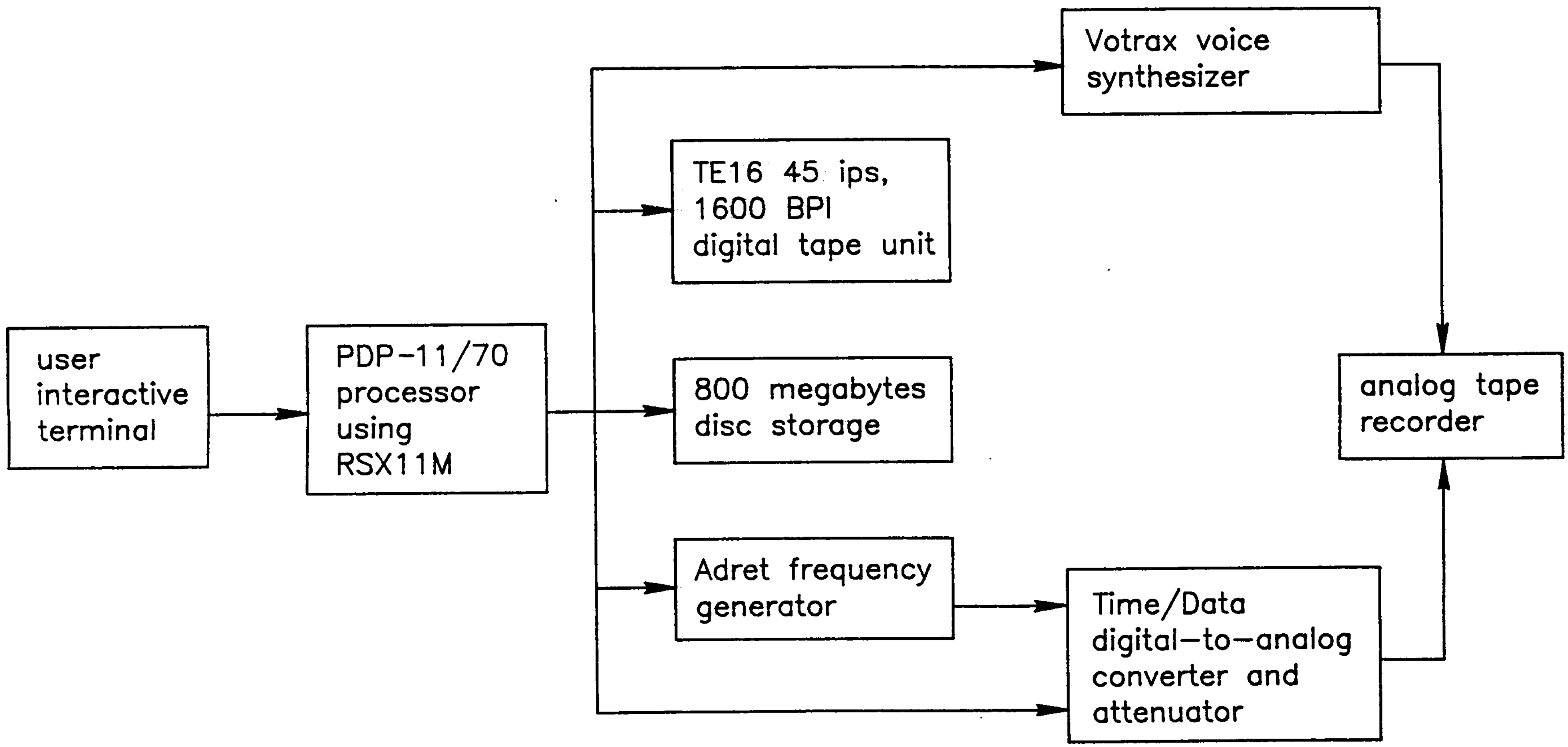


Figure 2. - Aircraft Noise Synthesis System hardware configuration.

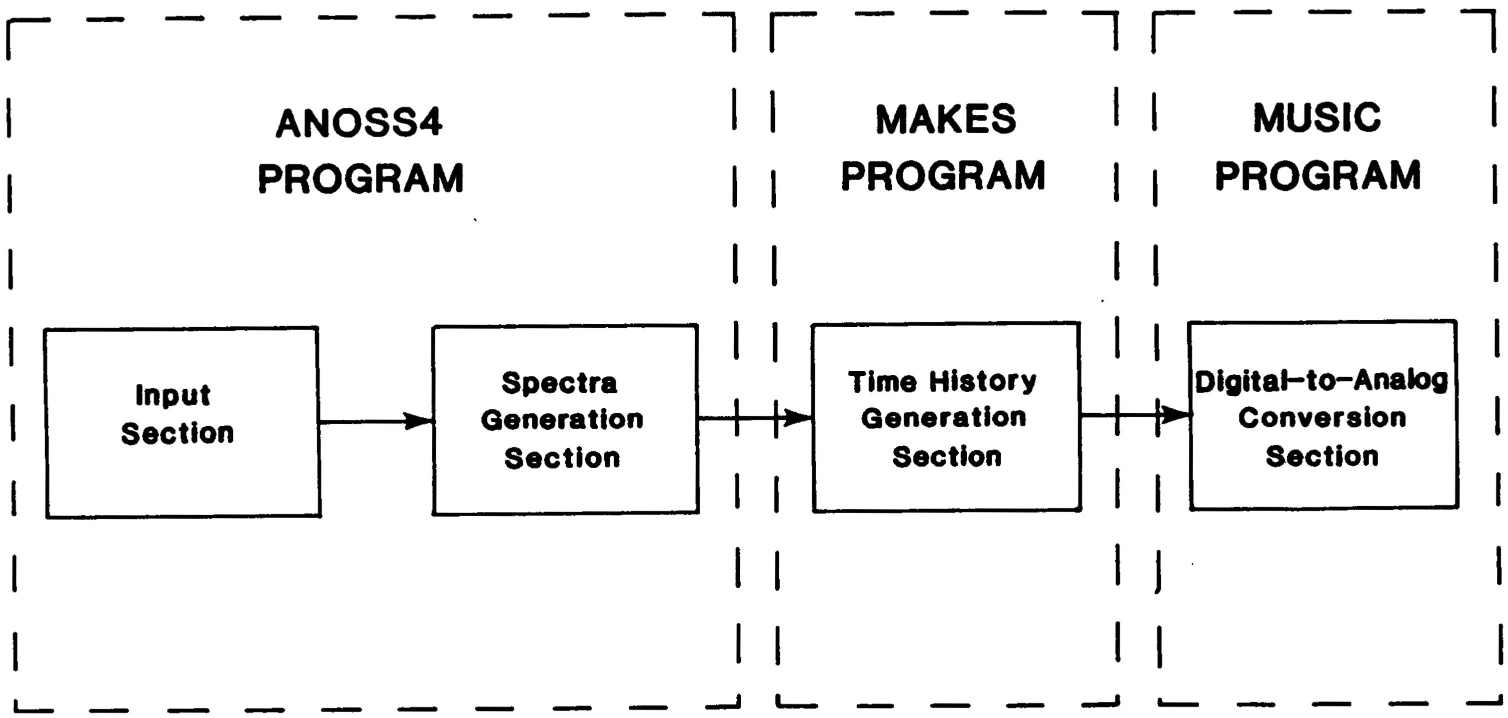


Figure 3. - Organization of Aircraft Noise Synthesis System software.

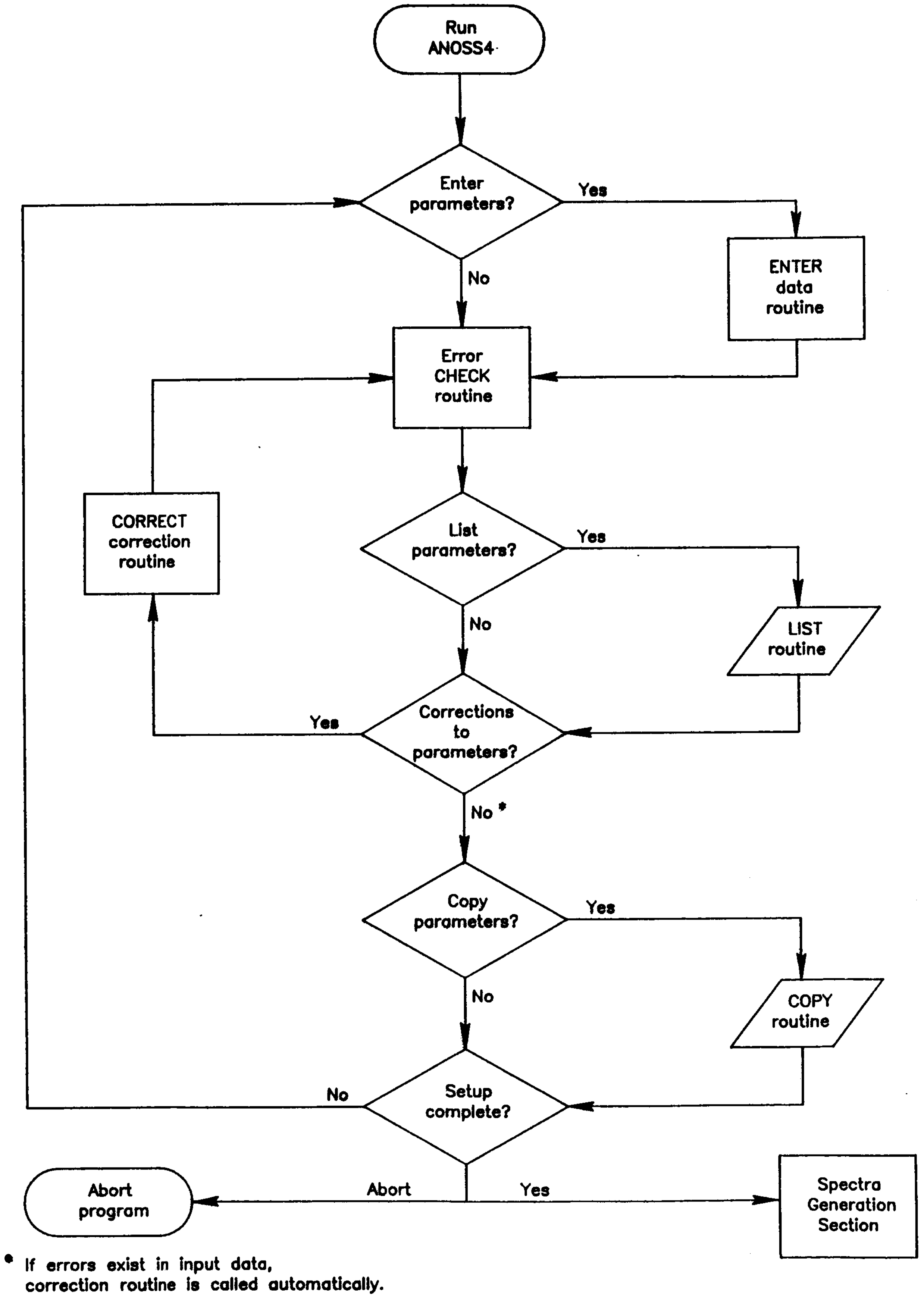


Figure 4. - Aircraft Noise Synthesis System (Version 4) input section flow chart.

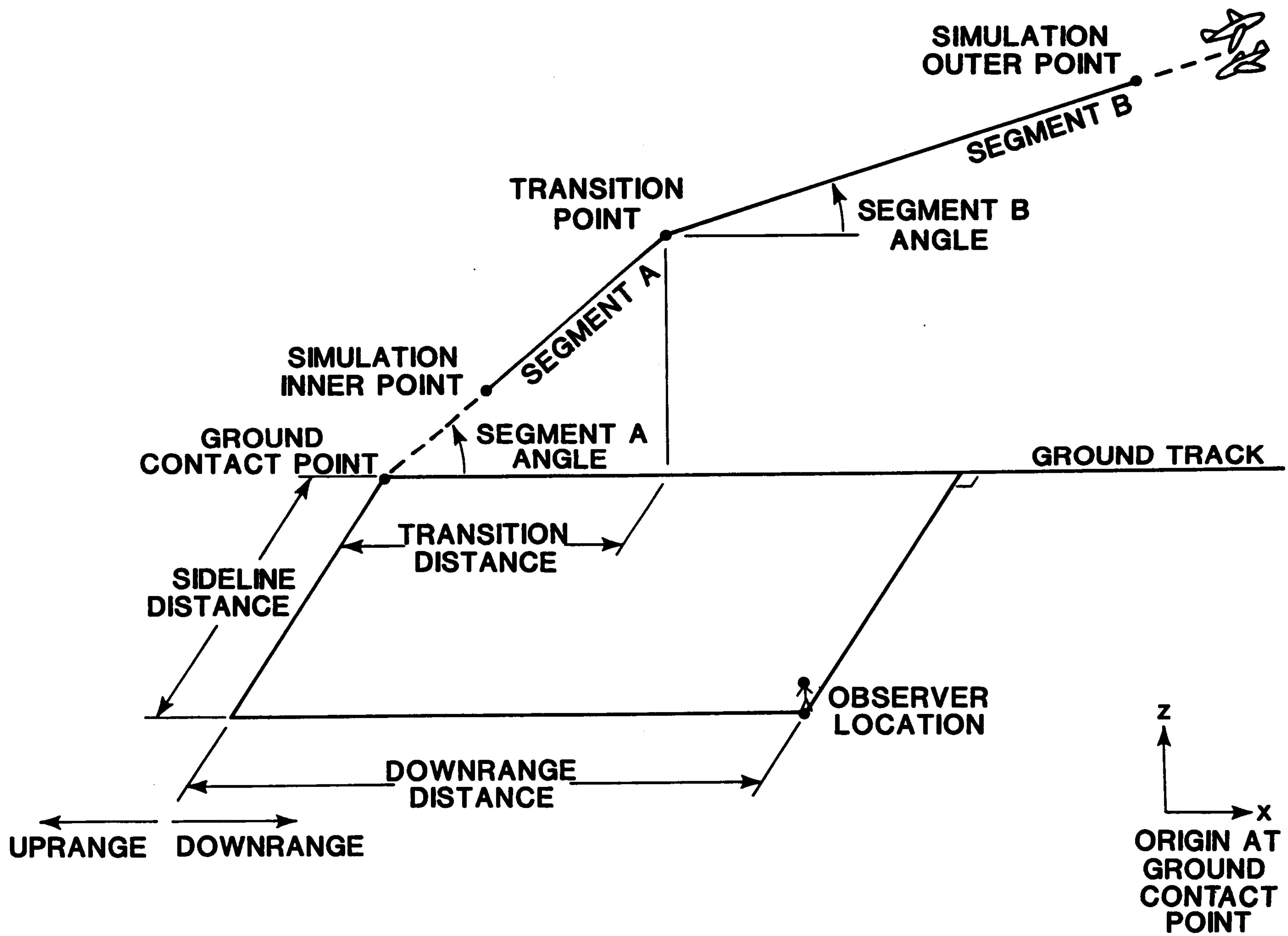


Figure 5. - Observer location relative to the aircraft flight path.

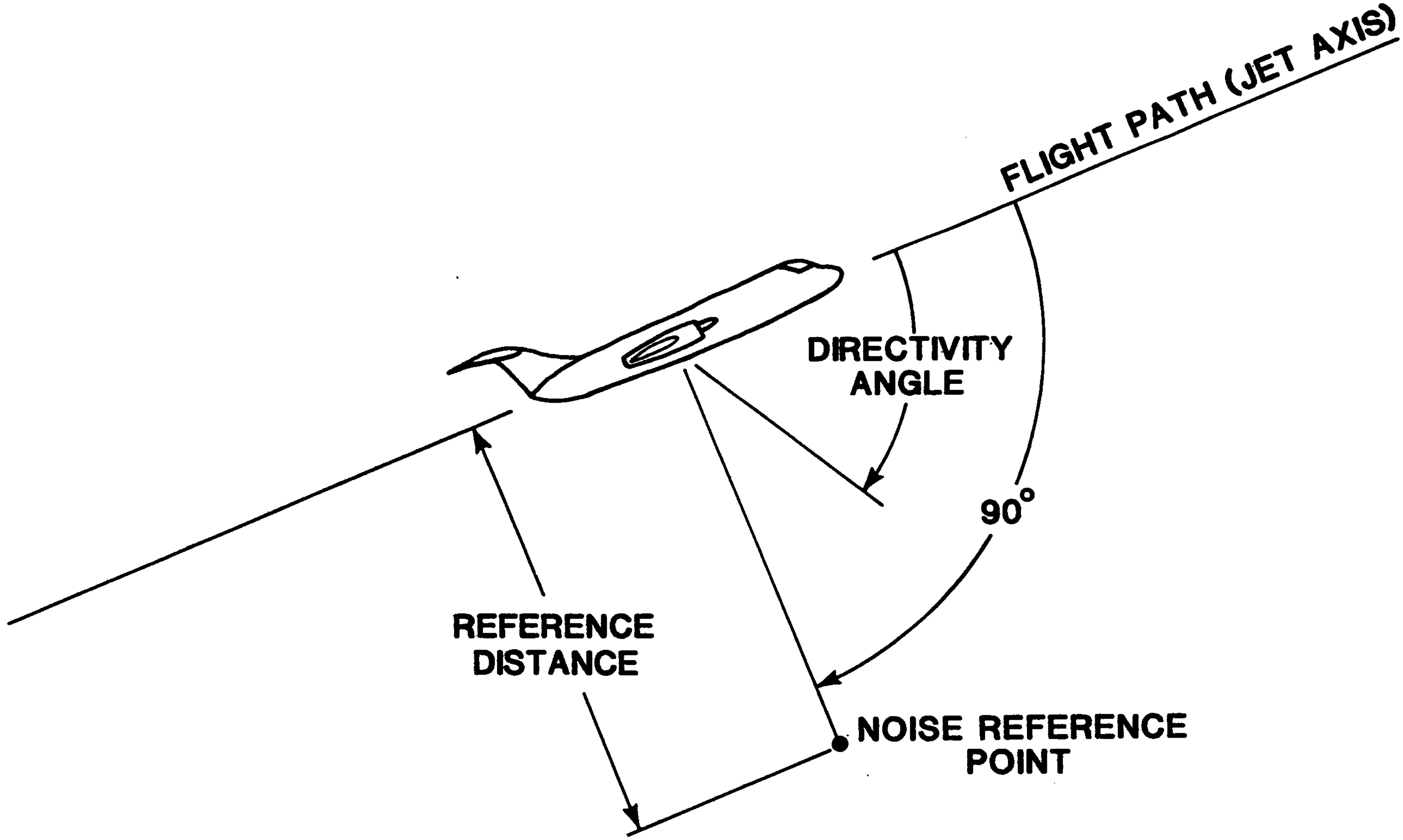
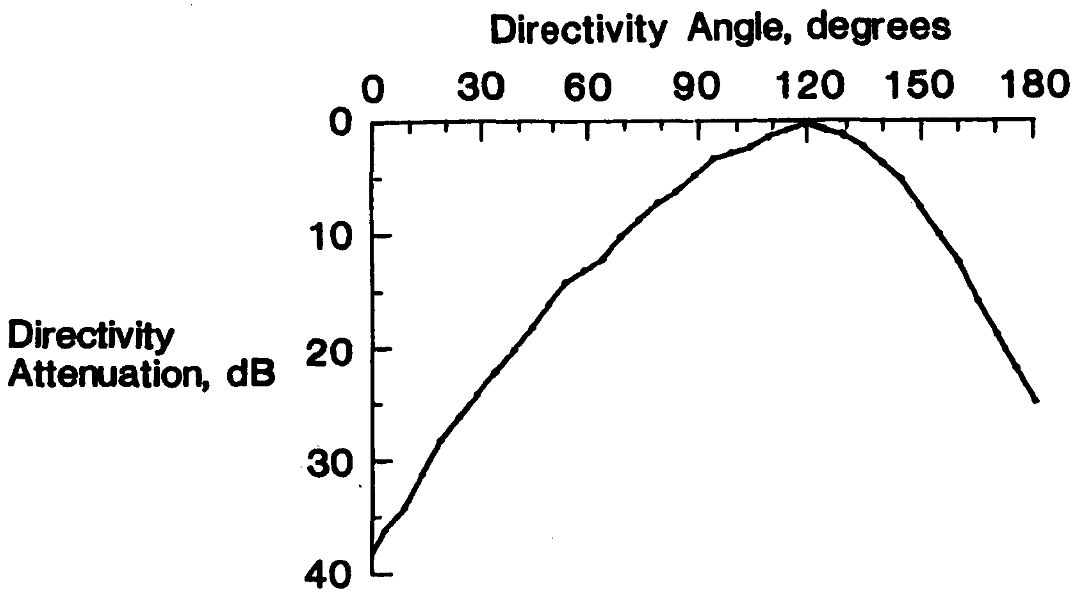
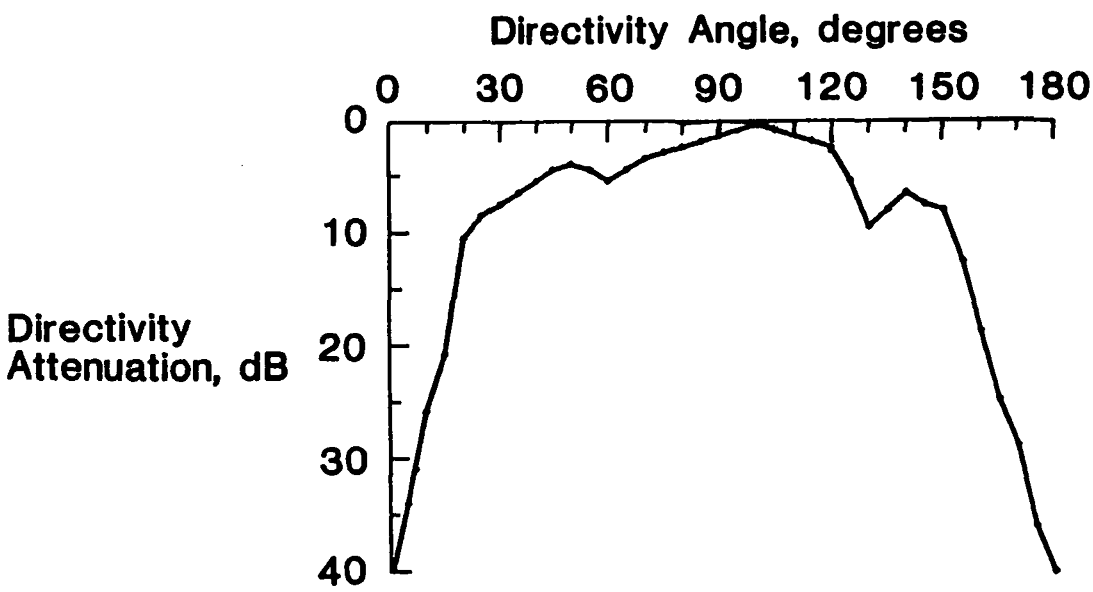


Figure 6. - Aircraft noise description reference frame.



(a) Directivity peak angle equals 120 degrees.



(b) Directivity peak angle equals 100 degrees.

Figure 7. - Examples of directivity patterns.

1. Report No. NASA TM-89089

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
AIRCRAFT NOISE SYNTHESIS SYSTEM:
VERSION 4 USER INSTRUCTIONS

5. Report Date
February 1987

6. Performing Organization Code
535-03-11-03

7. Author(s)
David A. McCurdy, Brenda M. Sullivan, and
Robert E. Grandle

8. Performing Organization Report No.

10. Work Unit No.

9. Performing Organization Name and Address
NASA Langley Research Center
Hampton, VA 23665-5225

11. Contract or Grant No.

13. Type of Report and Period Covered
Technical Memorandum

12. Sponsoring Agency Name and Address
National Aeronautics and Space Administration
Washington, DC 20546

14. Sponsoring Agency Code

15. Supplementary Notes
David A. McCurdy and Robert E. Grandle, Langley Research Center, Hampton, VA.
Brenda M. Sullivan, The Bionetics Corporation, Hampton, VA.

16. Abstract

A modified version of the Aircraft Noise Synthesis System with improved directivity and tonal content modeling has been developed. The synthesis system is used to provide test stimuli for studies of community annoyance to aircraft flyover noise. The computer-based system generates realistic, time-varying audio simulations of aircraft flyover noise at a specified observer location on the ground. The synthesis takes into account the time-varying aircraft position relative to the observer; specified reference spectra consisting of broadband, narrowband, and pure tone components; directivity patterns; Doppler shift; atmospheric effects; and ground effects. These parameters can be specified and controlled in such a way as to generate stimuli in which certain noise characteristics such as duration or tonal content are independently varied while the remaining characteristics such as broadband content are held constant. The modified version of the system provides improved modeling of noise directivity patterns and an increased number of pure tone components. User instructions for the modified version of the synthesis system are provided.

17. Key Words (Suggested by Author(s))
Aircraft Noise
Subjective Acoustics
Psychoacoustics
Synthesizer
Noise Simulation

18. Distribution Statement
Subject Category - 71
Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	30	A03